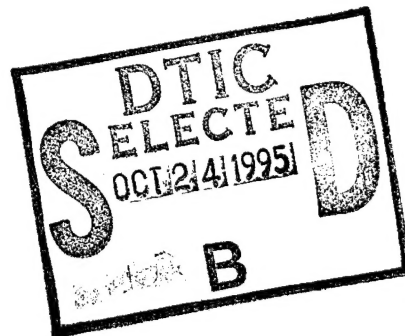


NATIONAL AIR INTELLIGENCE CENTER



COMPUTER ASSISTED LASER RANGE FINDING AND DETECTION SYSTEMS



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I. INTRODUCTION

Up to the present time, the majority of laser radars which have been reported were very expensive, had large volumes, and were very complicated in terms of utilization and maintenance. As far as this type of low cost laser range finding and detection system reported in this paper is concerned, use is made of a type of semiconductor laser diode emission device and a small model computer to do control. With regard to making use of semiconductor laser diodes to replace Nd: YAG lasers, the results were to improve optical emission efficiencies, electronic control compatibility, and reduce system dimensions. One type of high sensitivity PIN diode receiver is capable of receiving radar pulses reflected back from targets, and, in conjunction with that, directly supplying digital output. Electronic methods are used to measure laser pulse travel time of flight. In conjunction with that, an IBM-AT compatible minicomputer is used, and it is possible to realize the needed calculations as well as displaying target distance, speed, and position. Systems are capable of tracking horizon range targets more than 50m away from emitters.

* Numbers in margins indicate foreign pagination.
Commas in numbers indicate decimals.

II. HARDWARE STRUCTURE

A simplified system diagram is as shown in Fig.1. It is composed of the several subsystems below:

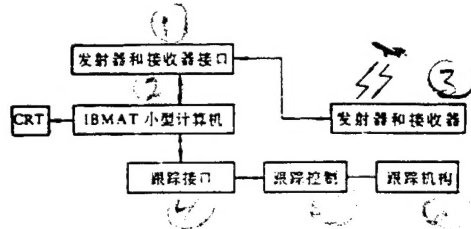


Fig.1 Computer Assisted Laser Range Finding and Detection System Schematic (1) Emitter and Receiver Ports (2) IBMAT Minicomputer (3) Emitter and Receiver (4) Tracking Connection

(5) Tracking Control (6) Tracking Mechanism

- (1) transmitter and modulator circuits,
- (2) receiver and computer modules,
- (3) tracking mechanisms and tracking control modules,
- (4) port circuitry associated with connecting IBM(AT) computers and the circuits described above,
- (5) receiver and transmitter optical systems,
- (6) tracking mechanism and mechanical hardware.

(I) Transmitter Circuits

The function of this circuitry is to initiate an approximately 60A current through a semiconductor laser diode. Taking two n-channel metallic oxide semiconductor

field effect transistor (MOSFET) connected in parallel. These are then connected in series to laser diodes. Through laser diode peak value currents, it is possible to regulate gate excitation voltages associated with one of the MOSFETT in order to add control. Laser diodes use 6.25kHz frequency continuous output pulses. In conjunction with that, regulated pulse duty cycles obtain maximum peak power values but do not damage diodes. /46

(II) Receiver and Computer Modules

Receivers receive laser pulses reflected back from targets. In conjunction with that, they directly supply digital output. Receivers, in actuality, are made up from a telescope acting as a light collecting aperture, a piezoelectric diode with an amplifier, and certain signal processing circuits. In the development of these, option was made for the use of Motorola Company MFOD2405 integrated detection device preamplifiers (IDP).

This type of preamplifier is made up of PIN diode detectors and integrated bipolar transresistance amplifiers possessing differential output levels. IDP output goes through further amplification, achieving ECL compatible piezoelectric levels.

The computer modules in question have an ECL computer. Stimulated by 100MHz crystal oscillators, they are capable of precisely determining the time intervals between transmitted and received laser pulses. After each transmitter pulse transmitted, in all cases, computers "recover". "Frozen" signals coming from receivers are all effective. Once signals reflecting back from targets are detected, they then cause counts to enter 16 bit gates.

(III) Tracking Mechanism

Use is made of conical scanning technology to detect and track targets. Using this type of method, one takes beam curvatures and rotations--not reaching 25ms--and then forms an integrated cone shaped laser beam. The principles and hardware used for this purpose are shown in Fig.2. Two precision cut trough prisms cut across polytetrafluoroethylene gear wheels installed on a piece of metal plate. In conjunction with this, it is rotated by a direct current electric motor. Making use of these two pieces of prism, light beams are curved--respectively forming 15° or 30° hemiconical angles. Tracking hardware moves conical beams in order to continuously capture targets. Use is made of a set of execution mechanisms selecting actual prisms. In conjunction with this, they are aligned with the main axis of laser beams. Use is made of step electric motors to make plate inclinations. As a result, prisms make light beams curve. Through mutual combinations of slanting and rotations, it is then possible to actualize conical scanning. In order to achieve rapid system response, moments of force associated with step electric motors should be reduced to a minimum.

Tracking control circuits are composed of phase locked loop (PLL) direct current motor speed control circuits, electric cables, encoding circuits, power devices/relay drive devices, and pulse suppressors. Target locations at time of detection can be calculated on the basis of the size of light beam rotation angles. Light beam rotation speeds use PLL electric motor control circuits for regulation. Rotation speeds are determined from target speed duty cycles.

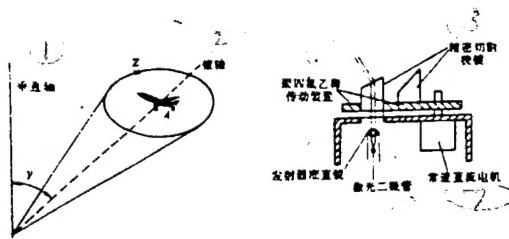


Fig.2 Hardware and Principles Used in Conical Scanning (1) Vertical Axis (2) Cone Axis (3) Precision Cut Prism (4) Polytetra fluoroethylene Rotating System (5) Transmitter Collimation Lens (6) Laser Diode (7) Constant Speed Direct Current Electric Motor

An IBM(AT) compatible minicomputer is used to complete the necessary calculations. In conjunction with this, distances and target positions are displayed. It is also possible to do new alignments for control signals produced by step electric motors. Connection modules are designed to be able to make counts and relevant data output to central processing units (CPU) to carry out calculations and produce control signals. Minicomputers are also capable of estimating possible target flight directions and control tracking hardware mechanisms. Once targets are discovered, monitoring is then continuous. In conjunction with this, together with other parameters, displays appear on computer screens. After detecting targets and during continuous tracking periods, computers are capable of supplying a type of output signal to use in order to control exterior equipment.

III. SOFTWARE DEVELOPMENT

As far as software used in various subsystems as well as parameter calculations is concerned, use is already made of Turbo Pascal which is capable of writing program sentences. Programs are written using modular forms. When necessary, it is possible to provide convenient corrections. The full flow chart for working out software is shown in Fig.3. The important problems when writing software include user friendliness, efficiency, and accuracy. The compilation of software will cause it to utilize standard DOS operations on minicomputer systems--whether they are any IBM or compatible. In conjunction with this, it is required

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on systems to have the presetting of a command channel beforehand.

Software includes: automatic, artificial, parameter setting, and withdrawal methods. Automatic methods display a three color (not shown in the Fig.) arc light clearly showing tracking systems in operation. Once targets, ranges, speeds, and positions associated with spherical coordinates are detected, then they will be displayed on screens. Besides this, software is capable of making systems continuously track targets, and, in conjunction with this, display calibrated data. When targets are outside scanning areas, systems will then be restored, and, in conjunction, show the reappearance of three colored arc light. After that, systems make one iteration of detection preparations, and, in conjunction with that, continue to execute programs, continuing right on until appropriate commands to withdraw automatic modes are received and then

stopping. In artificial methods, it is possible, in all cases, to complete various types of subsystems--for example, measurements and tests on transmitter, receiver, drive, cone axis alignment, and electric equipment speed control software. Using artificial methods, at any single instant, it is also possible to precisely determine and display distances. Parameter preset methods allow changes in system parameters to include step motor resolution, direct current motor speed/fundamental frequency and calculation frequency. Withdrawal methods will make transformation programs input to DOS. Tracking software test modes and micro machines used in this research are shown together.

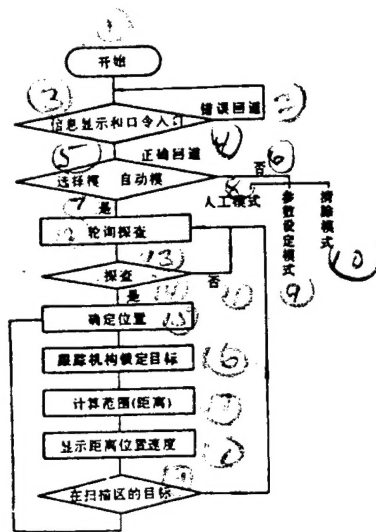


Fig.3 Software Development Flow Chart (1) Start (2) Error Loop (3) Information Display and Command Entry (4) Correct (illegible) Loop (5) Selection Mode Automatic Mode (6) No (7) Yes (8) Artificial Mode (9) Parameter Setting Mode (10)

(Illegible) Mode (11) No (12) Rotating Search (13) Search (14) Yes (15) Determine Position (16) Tracking Mechanism (illegible) Fix Target (17) Calculation Range (Distance) (18) Display Distance, Position, and Speed (19) Targets in Scanning Area

IV. CONCLUSIONS

Obviously, this type of flexible and user friendly system has broad applications. Results clearly show that semiconductor laser diodes have potential applications in the area of range finding. They also clearly show that laser range finding system performance is good and construction costs are low. Systems capabilities also clearly show that minicomputers not using mainframes/minicomputers alternatively based on the system in question developing composite micro machines are then capable of completing even more calculation work. The

system, with some added improvements and the assistance of appropriate connections- -such as, RS-232 and/or IEEE-488, is capable of connection to other instruments. Moreover, it is also capable of supplying appropriate control signals to drive other relevent systems.

REFERENCES

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